(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
7 February 2002 (07.02.2002)

PCT

(10) International Publication Number
WO 02/09612 A1

(51) International Patent Classification[7]: A61C 13/09, 13/00

(21) International Application Number: PCT/US01/23933

(22) International Filing Date: 30 July 2001 (30.07.2001)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
60/221,720 31 July 2000 (31.07.2000) US

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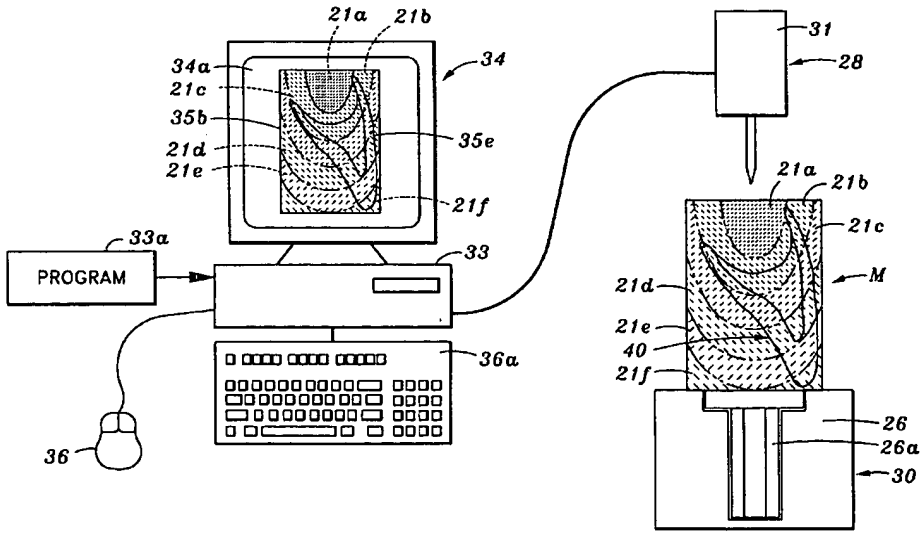
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

[Continued on next page]

(54) Title: MILLABLE BLOCKS FOR MAKING DENTAL PROSTHESES, ASSOCIATED DENTAL PROSTHESES AND METHODS OF MAKING



(57) Abstract: A dental prosthesis comprises a platform adapted to be attached to a milling machine and a piece of material from which the dental prosthesis is to be made mounted to the platform. The piece of material has plurality of gradations having different color densities similar to different color densities of a tooth, or portions of a tooth, that the dental prosthesis is to replace. These different color densities of gradations vary through out the piece of material in a pattern similar to a pattern of variation in color density of the tooth, or portions of a tooth, that the dental prosthesis is to replace. The gradations gradually vary in shades of color from a lighter to a darker color density whrere the lighter colored gradations correspond to enamel coloration and the darker colored gradations correspond to dentin coloration.

WO 02/09612 A1

— *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments*

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MILLABLE BLOCKS FOR MAKING DENTAL PROSTHESES, AASOCIATED DENTAL PROSTHESES & METHODS OF MAKING

RELATED PATENT APPLICATION

This application is a utility application based on U. S. provisional patent application Serial No. 60/221,720, entitled "Millable Blocks For Dental Prostheses," filed July 31, 2000. This related provisional application is incorporated herein by reference and made a part of this application.

BACKGROUND OF THE INVENTION

For many years dental prostheses have been made for patients who have lost any number of their natural teeth. Prostheses may be in the form of crowns, bridges, inlays, or dentures. Of prime interest to a patient needing artificial teeth is their appearance. The patient expects his or her dentist to be able to restore missing teeth with prostheses that both function comfortably for biting and chewing food and look esthetically pleasing. Dentist requiring such prostheses often employ the services of a dental laboratory outfitted with manufacturing equipment, including computer aided design and manufacturing equipment (CAD/CAM), which employs technicians skilled in building such prostheses.

Dental prostheses are often made of dental construction material such as, for example, ceremer or composite, plastic or ceramic such as porcelain. The material that is used is the choice of the patient and dentist. Usual procedures include the dental office making an

impression of the patient's tooth or teeth that need to be replaced. The impression is sent to the dental laboratory where the prosthetic tooth or teeth are produced from milling blocks of the dental construction material.

In dentistry, the milling blocks used are solid blocks typically of composite, plastic or porcelain that may be cylindrical, or cubic in shape. Their size and shape are dependent on the size and type of the prosthesis they will make. Their size and shape will also depend on the CAD/CAM or other automated milling equipment. Milling transforms the block into a dental prosthesis, restoring the anatomy, function and esthetics of the coronal portion of the natural tooth or teeth. In dentistry, coronal refers to the full shape and form of the outside of a tooth

CAD/CAM equipment, including the computer software that enable them to build dental prostheses, are a growing part of dental laboratory technology. From about the 1980's, CAD/CAM equipment has been used in the dental laboratory. Although beginning as a slow and expensive process, recent developments in software technology have made CAD/CAM equipment more widely used. Firms that currently make such equipment for use in the dental industry include Sirona, Cynovad, formerly Dental Matic, DECIM, CAD/CAM Ventures, Kavo, Degusa, and DCS. Since the patient's dental restoration will be visible to others, most dentists and patients are eager to have prostheses that are esthetically pleasing. If the prosthesis is for only one or two teeth and the patient has mostly natural teeth, a good match between the prosthesis and the natural teeth is very highly desirable. Currently, dental laboratories making prosthesis have three choices. First, they may use a block of dental construction material that is monochromatic and mill away unwanted material. Any

prosthesis made from the monochromatic block is monochromatic as well. Second, they may build a stack of layers of dental construction material using a material of the same color hue for each layer, but selecting for each individual layer a material of different densities Each layer has a slightly increasing density, with the least dense layers corresponding to an enamel color density and the more dense layers corresponding to a dentin color density. The dental technician performs this task by hand, building the prosthesis layer-by-layer. Third, they may hand-color the prosthesis, which is an extremely laborious and time-consuming technique.

Complete matching of the prosthesis to the remaining natural teeth or tooth that is replaced is extremely difficult. The structure of the tooth influences its color. Dentin, which is one of the internal layers of the tooth is more opaque than the tooth's external enamel. Dentin and enamel reflect light differently. Enamel is a crystalline layer over the dentin and is composed of tiny prisms or rods cemented together by an organic substance present in a natural tooth. The indices of refraction of the rods and cement material present in enamel are different than those of the dentin. Consequently, a light ray that hits tooth enamel is diffused by reflection and refraction to produce a translucent effect and a sensation of depth as the scattered light reaches the eye. As a light ray strikes a tooth surface, part of it is reflected and the remainder penetrates the enamel and is diffused. Light reaching the dentin is either absorbed or reflected to be again diffused in the enamel. If dentin is not present, as is the case in the tip of an incisor, some of the light ray may be absorbed in the dark oral cavity. Consequently, this area may appear to be more translucent than the tooth area toward the gingival.

In addition to the reflection and refraction of light, there may

also be some light dispersion. Dispersion gives the tooth a color or shade which varies in different teeth. Since dispersion varies with wavelength of light, the appearance of natural teeth will vary depending on whether they are viewing in direct sunlight, reflected daylight, fluorescent light, and the like. Since the structure of natural teeth reflects light polychromatically, it is desired that dental prostheses do the same.

SUMMARY OF THE INVENTION

Broadly, this invention is centered on a millable block for making permanent or removable dental prostheses such as denture teeth, inlays, crowns and bridges. It comprises graduated, multi-shaded densities of dental construction material distributed to cause light to reflect polychromatically from a prosthesis milled from this material. This invention has several features, no single one of which is solely responsible for its desirable attributes. Without limiting the scope of this invention as expressed by the claims that follow, its more prominent features will now be discussed briefly. After considering this discussion, and particularly after reading the section entitled, "DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS," one will understand how the features of this invention provide its benefits, which include, but are not limited to, convenience of use, ease of manufacture, and improved appearance of dental prostheses.

The first feature of the millable block of this invention is that it includes a piece of dental construction material suitable for making a dental prosthesis. Suitable materials are composite (a mix of plastic and ceramic), plastic, and ceramic, such as, for example porcelain. This piece of dental construction material may have many different

shapes, for example, cubical, cylindrical, or other elongated forms with cross-sections such as, for example, hexagonal, oval, octagonal, etc. The material comprises a plurality of multi-shaded gradations of different color densities of dental construction material. This piece of dental construction material is of a suitable large enough size so that the desired prosthesis may be milled from it. The piece of dental construction material may be configured for attachment directly to a milling machine, or it may be mounted to a platform that is attached to a milling machine.

The second feature is that multi-shaded gradations of dental construction material may be discrete layers of different shades of color similar to different shades of color of a tooth, or portions of a tooth, that the dental prosthesis is to replace. The discrete layers vary gradually in shades of color density from a lighter to a darker shade of color density. The lighter shade of color density corresponds to enamel coloration and the darker shade of color density corresponds to dentin coloration. Preferably, the number of layers is from 2 to 30. The layers may be substantially parallel to each other, or they may be substantially cup shaped and nested together. These layers may be of substantially equal thickness, or they may vary in thickness, with the layers becoming gradually thicker as they progress from the lighter, or least dense coloration, to the darker, or more dense coloration. Typically, the thickness of an individual layer is from 0.05 to 3 millimeters (mm). The important aspect is that the different shades of color density of the layers vary in color shade through out the piece of material in a pattern similar to a pattern of variation in color density of the tooth, or portions of a tooth, that the dental prosthesis is to replace.

This invention also includes any prosthesis made from the

millable block of this invention and methods of making a dental prosthesis:

One method comprises the steps of

(a) providing a piece of material having a plurality of discrete layers of different color densities similar to different color densities of a natural tooth, or portions of a tooth, that the dental prosthesis is to replace, and

(b) milling the piece of material to cut away material from the piece of material in a predetermined manner so that the dental prosthesis has a color density pattern similar to a pattern of variation in color density of the natural tooth, or portions of a tooth, that the dental prosthesis is to replace.

Another method comprises the steps of

(a) providing a piece of material having a plurality of discrete layers of different color densities similar to different color densities of a natural tooth, or portions of a tooth, that the dental prosthesis is to replace,

(b) providing a milling machine including a programmable computer including a monitor screen,

(c) displaying an image of the prosthesis on the monitor screen within an image of the piece of material,

(d) orienting the image of the prosthesis relative to the image of the piece of material for controlling the milling the piece of material in a predetermined manner in accordance with the orientation, so that the dental prosthesis has a color density pattern similar to a pattern of variation in color density of the natural tooth, or portions of a tooth, that the dental prosthesis is to replace, and

(c) milling the piece of material in the predetermined manner to cut away material from the piece of material and form the dental

prosthesis.

This invention also includes a method of making a piece of material used for making a dental prosthesis. This method comprises stacking together discrete layers of prosthesis construction material having different color density similar to different color density of a tooth, or portions of a tooth, that the dental prosthesis is to replace. The discrete layers vary gradually in color density from a lighter to a darker color where the lighter color corresponds to enamel coloration and the darker color corresponds to dentin coloration. The layers are arranged in a color density pattern similar to a pattern of variation in color density of the natural tooth, or portions of a tooth, that the dental prosthesis is to replace. The stacked layers are formed by molding, extruding, or forging.

DESCRIPTION OF THE DRAWING

The preferred embodiment of this invention, illustrating all its features, will now be discussed in detail. This embodiment depicts the novel and non-obvious millable block for making dental prostheses and method of making such dental prostheses as shown in the accompanying drawing, which is for illustrative purposes only. This drawing includes the following figures (Figs.), with like numerals indicating like parts:

Fig. 1 is a cross-sectional view of a natural, front incisor tooth.

Fig. 2 is a side elevational view of the first embodiment of the millable block of this invention.

Fig. 3 is a perspective view of the second embodiment of the millable block of this invention mounted on a platform to be attached

to a milling machine.

Fig. 4A is a cross-sectional view taken along line 4A-4A of Fig. 3.

Fig. 4B is a cross-sectional view taken along line 4B-4B of Fig. 3.

Fig. 5 is a schematic view of a milling machine for making one type of dental prosthesis shown in Figs. 6A and 7A from the second embodiment of the millable block shown in Fig. 3.

Fig. 6 is an enlarged cross-sectional view of the millable block being used with the machine depicted in Fig. 5. The cross-sectional view has an image of the prosthesis to be made from this block superimposed thereon to indicate how the different density layers are to be disposed within the prosthesis after milling.

Fig. 6A is a cross-sectional view of a dental prosthesis made using the machine depicted in Fig. 5 with the different density layers disposed as indicated in Fig. 6.

Fig. 7 is a cross-sectional view taken along line 7-7 of Fig. 6.

Fig. 7A is a cross-sectional view taken along line 7A-7A of Fig. 6A.

Fig. 8 is a perspective view of the millable block shown in Figs. 3 and 5 wherein an image of a second form of prosthesis having different graduated, multi-shaded densities than the prosthesis depicted in Figs. 6A and 7A is made from this same block milling it in a different manner.

Fig. 8A is a cross-sectional view of the second form of dental prosthesis made from the millable block shown in Fig. 4A by cutting away material in a different manner. A cross-sectional view of the millable block of Fig. 4A is superimposed on this cross-sectional view Fig. 8A.

Fig. 9 is a schematic view of the milling machine shown in Fig. 5 making another type of dental prosthesis shown in Fig. 8A from another millable block identical to the block used to make the

prosthesis shown in Fig. 6A and 7A.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

General

A multi-shaded millable block of this invention is used with a CAD/CAM or other automated milling equipment for making dental prostheses. The millable blocks of the current invention are made with a variety of shades or color densities of a certain tooth color. The invention represents an improvement over the prior art millable blocks, which were monochromatic. Since there was no color variation in the prior art millable blocks, the prostheses made from them were often unacceptable to the dental laboratory customer, both dentists and patients.

The prosthesis made from the multi-shaded millable block of this invention will have an inherent natural appearance because of the color or density variation of the multi-shade millable block. The multi-shade millable block of this invention may be made from any material intended to match natural tooth color including plastic or porcelain. The following EXAMPLES describe producing a multi-shaded millable blocks on a laboratory, or small, scale. Tooth color is defined as the diversity of shades and intensity of color found in a natural tooth. For making dental prostheses, tooth colors are selected from industry-accepted standards. There are several industry standards including shade guides such as Vita (made by Vita), Bioform (made by Dentsply), and Chromascop (made by Ivoclar). In this example, Vita shades will be used as a shade guide in the following Vita shades for teeth are used for making dental prostheses with various color hues. The density of

the color present for each hue is classified on a numerical scale with lower numbers indicating less color density and higher numbers indicating higher color density.

The following non-limiting, laboratory scale examples are for illustrative purposes. It is to be understood that with appropriate modification, the procedures can use used on a large scale as well. Production of the multi-shaded millable block in larger size may be used to manufacture bridges, dentures, or other dental prostheses with multiple units.

EXAMPLE I

To make a millable block of this invention, the following procedure, done on a laboratory scale, is used

A mold that is about eight mm wide, about 20 mm deep, and about two cm long is cleaned and prepared to receive a first layer of dental construction material. The mold may be made from a variety of metals or rubber. A preferred mold material used in this embodiment is stainless steel and the material used therein is composite.

In dentistry, composite materials are a three-dimensional combination of synthetic polymers. Composites consists of a resin matrix, fillers, and coupling agents. These materials are combined and supplied commercially in a variety of forms, including powder and liquid, two-paste systems, and paste-liquid combinations. Examples of commercially available dental composites that may be used to make the millable composites of this invention include Targis (distributed by Ivoclar and Cristobal+ (distributed by Dentsply)For purposes of this invention, manufacturer's suggestions should be followed when mixing each layer. Usually, the materials solidify rapidly and should be thoroughly mixed to insure a homogeneous distribution of all components. Into the mold is placed a first layer of Cristobal+ composite about ___mm thick. The first layer has the highest color density and is the darkest. The

darkest layer represents 100% body color. The first layer of composite in the mold is then flattened with a spatula. The technician will have selected a mold deep enough for the number of layers necessary to complete a millable block suitable for the tooth to be produced from it and the milling machine that will produce it.

The number of layers in this example is 4. The number that is used for any particular millable block, however, depends on the coloration of the patient's natural tooth. The multi-shaded millable block is made so that its color density will match that of the patient's natural dentition. The thickness of each individual layer will approximate the gradations in color density of a tooth near by the location where the prosthesis is to be inserted or attached.

After the first layer (100% body or dentin color, labeled B in Fig. 2) of composite is placed in the mold and flattened, the next layer of composite is slightly lighted in color than the first. Each new layer is placed upon the previous layer in the mold. Each layer is flattened and slightly lighter that the previous. The final of composite will be the lightest, or 100% incisor color, labeled I in Fig. 2.

The continued building the multi-shaded millable block of this invention depends on the total number of layers desired. If, for example, twenty layers of color are desired, the second layer 19b will be 95% body color and 5% incisor color. Likewise, the next layer of composite in the mold will be 90% body color and 10% incisor color. The gradual addition of lighter shading to each layer of composite continues until the final (top) layer in the mold is the lightest and corresponds to 100% incisor color. In other words, the gradations in color density may be achieved by mixing different proportions of dentin color and incisor color.

The multi-shade millable block formed of the composed material is then cured with ultra-violet light and then, preferably, fired in a kiln. When curing by ultra-violet light is desired, the millable block is placed in a uv chamber. The chamber emits ultraviolet radian energy in the form of light of wavelength range of 4 to 400 nanometers which is absorbed by the millable block for a period of about 20 minutes, after which it becomes

solid. Subsequent heat curing for a composite or plastic millable block polymerizes the resin matrix, fillers, and coupling agents. Typically, the mixture is heated to a temperature that may reach as high as 140 degrees C for a period of time of about 20 minutes.

EXAMPLE II

A millable block of this invention may also be made of a porcelain material. Different layers are formed in a mold as discussed above. When the material used in the millable block is porcelain, curing takes place in a kiln where the millable block is fired. Firing of dental material is accomplished by placing the millable block on a fire-clay slab or tray and inserted into a porcelain furnace. Each firing cycle takes about 20 minutes.

When the multi-shaded millable block is finished and cured, a dental prosthesis is fabricated from it. This is done by using computer aided design equipment. First, a model of a patient's dentition is made, including surfaces corresponding to the dental structure nearby the location that the dental prosthesis is to be placed in the mouth of a patient. The surfaces of the model are scanned to collect three dimensional digital data corresponding to these surfaces. An image of the proposed dental prosthesis based, at least in part, on the collected three dimensional digital data corresponding to these surfaces is displayed on a monitor screen of computer aided design equipment. With the aid of the computer aided design equipment, an image of the millable block, including images of the zones corresponding to the different color densities through out the material are also displayed on the monitor screen. Such systems include Cynovad, formerly Dentalmatic Technologies, Inc. Cynovad provides optical 3D scanning for making models of patients' dentition and the ability to micro-mill a variety of materials including composite, plastic, and porcelain.

Another CAD/CAM system available for fabricating dental prostheses is Cerac systems provided by the Sirona Company. Cerac is a computer-aided design system that allows chairside restorations in the dental office. The multi-shaded millable blocks of this invention may be used for such restorations as well as those done in a dental laboratory.

The finished prostheses fabricated from the multi-shaded millable blocks of this invention restore the anatomy, function and esthetics of the coronal portion of the natural dentition that it replaces.

Illustrative Embodiments

As illustrated in Fig. 1, a natural tooth 10 comprises a core 12 having an internal cap 14 that is cover with a layer 16 of dentin material. The exterior of the tooth 10 comprises a layer 17 of enamel supported by the dentin layer 16. An intermediate portion 10b of the tooth 10 has a much darker or denser coloration than the tip 10a of the tooth 10, which has a lighter, translucent coloration. The root portion 10c of the tooth has the darkest or most dense coloration.

Each millable block 18 and 18a comprises a series of stacked together discrete layers L and La, respectively, of dental construction material of varying color shades or densities. These millable blocks 18 and 18a may have a cubical shape as shown or other shapes such as, discussed above. The layers L and La have different color shades arranged in a pattern similar to different shades of color of a tooth, or portion of a tooth, that the dental prosthesis is to replace. These layers L and La vary gradually in shades of color from a lighter to a darker color where the lighter color corresponds to enamel coloration and the darker color corresponds to dentin coloration. These layers L and La may be of equal thickness, or may vary in thickness with the layers

becoming gradually thicker as they progress from the lighter, or least dense coloration, to the darker, or more dense coloration.

The millable block 18 has its layers 19a through 19r in parallel, with the most dense, or darkest color, being layer 19a and the lightest, or least dense layer, being the layer 19r. As shown in Fig. 2, the intermediate layers 19b through 19q gradually decrease in density, or become lighter in color, in an incremental, step-wise fashion, with each adjacent layer becoming less dense or lighter in color as the layers progress from one side 18d of the block 18 to an opposed side 18c of this block. For example, the layers 19a through 19f are the darker colors and correspond to dentin coloration and the layers 19g through 19r are the lighter colors and corresponds to enamel coloration.

The millable block 18a has the most color dense layer 21a formed into a rounded, conical shape. The other graduated, less dense layers 21b through 21f are stacked sequentially on this core layer 21a. The layers 21a through 21f of the millable block 18a substantially cup shaped and nested together. These layers 21a through 21f gradually decrease in density, or become lighter in color, in an incremental, step-wise fashion, with each adjacent layer becoming more dense or darker in color as the layers progress from one side 24a of the block 18a to an opposed side 24b of this block.

The millable block 18 does not have a platform and the millable block 18a has a platform 26. Consequently, the millable block 18 is clamped directly into an automated milling machine. In contrast, the block 18a includes a cubical piece of dental construction material M having an end 24b glued, or otherwise attached, to a platform 26 having a stem 26a with a hexagonal cross-section. The block 18a may be used with a milling machine 28 such as depicted in Fig. 5 that includes a chuck 30 specifically designed to grasp the stem 26a of the

platform 26. Another type of milling machine (not shown) may be used with the block 18 that has a clamp (not shown) that grips the block directly. In either case, the machine 28 includes a cutting tool 31 that cuts-away unwanted material from the millable block 18 or 18a. Preferably, the milling machine 28 is of the automated type such as sold by Cynovad. Such a milling machine 28 is selectively programmable to cut the block 18a in different ways to produce prostheses with different color density patterns from blocks having the identical layer pattern. For example, an incisor prosthesis 20 (Figs. 6A and 7A) and another incisor prosthesis 40 (Fig. 8A) having a different density pattern than the prosthesis 20 may each be made from two identical blocks 18a (Figs. 3, 4A and 4B). The dental prosthesis 20 and the dental prosthesis 40 each have a variation in color density similar to the pattern of coloration in the natural tooth, or portions of a tooth, being respectively replaced by each of these dental prostheses.

To manufacture the two dental prostheses 20 and 40 starting with millable blocks 18a having identical layer construction, an image of the prosthesis to be made and an image of the piece of dental construction material M displayed in a manner that they may be compared to each other. The image of the piece of dental construction material includes images of the different layers, or at least lines corresponding to the boundaries between layers. This enables the two images to be orientated selectively relative to each other to indicate how the different density layers are to be disposed within the prosthesis after milling,

The milling machine 28 includes a programmable computer 33 and a monitor 34 that displays images on its screen 34a. To manufacture the two dental prostheses 20 and 40 starting with millable blocks 18a having identical layer construction, an image of the

prosthesis to be made and an image of the piece of dental construction material M are selectively orientated on the monitor screen 34 to indicate how the different density layers are to be disposed within the prosthesis after milling.

To make the prosthesis 20, an image 35a of the incisor prosthesis 20 and an image 35b of the block 18a are displayed in the screen 34a. and their orientation with respect to each other is selected. The image 35b is a cross-sectional view of the block 18a showing images 21a' through 21f' of the different layers 21a through 21f and the image 35a is a cross-sectional image of the prosthesis to be made superimposed on the image 35b of the block. Through an input device such as, for example, a mouse 36 or keyboard 36a, a dental technician manipulates these images 35a and 35b on the screen 34a to change the orientation of the image 35a of the prosthesis relative to the images 21a' through 21f' of the different layers 21a through 21f within the block 18a, placing the cutting or leading edge 32a of the prosthesis 20 in the layer 21e.

After selecting the desired orientation of the images 35a and 35b, the technician actuates the milling machine 28 to operate the cutting tool 31. The computer 33 has a program 33a that controls the operation of the tool 31 to cut away material from the block 18a in the same manner as the relative orientation of the images 35a and 35b on the screen 34a. This enables the dental technician to select the layer arrangement or density pattern of the prosthesis. For example, the image 35a corresponds to the prosthesis 20 oriented with its longitudinal axis X at a right angle to the top planar surface 26b of the platform 26 and co-extensive with the longitudinal axis of this platform. The tool 31 cuts unwanted material from the block 18a to produce the prosthesis 20 with the leading edge 32a of the prosthesis

20 seated in the layer 21e and the layers 21a through 21e at right angles to the longitudinal axis X.

Figs. 8, 8A and 9 depict a different orientation of images than that shown in Figs. 5, 6, 6A, 7 and 7A. Fig. 8 shows an image 35e of the prosthesis 40 as it is to be oriented relative to the different layers 21a through 21f of the block 18a. In this instance, the image 35b of the block 18a is shown on the screen 34a in cross-section like that shown in Fig. 5 and an image 35e of the prosthesis 40 is shown superimposed on the image 35b. Using an input device, for example the mouse 36 and/or keyboard 36a, the technician has oriented on the screen 34a the image 35e of the incisor prosthesis 40 off the axis of the image 35e of the block 18a so that the longitudinal axis X of the incisor prosthesis 40 is along a diagonal line extending from one corner **a** to an opposed corner **b** of the image of the block 18a. As shown in Fig. 8A, the leading edge 32b of the prosthesis 40 is now seated in the layer 21f (layers 21a through 21f shown in phantom) of the block 18a. Upon cutting away unwanted material from the block 18a in accordance with the relative positions of the images 35b and 35e displayed in the screen 34a, the off axis orientation and re-positioning to the leading edge 32b of the prosthesis 40 creates an entirely different density pattern in the prosthesis 40 than that of the prosthesis 20.

SCOPE OF THE INVENTION

The above presents a description of the best mode contemplated of carrying out the present invention, and of the manner and process of making and using it, in such full, clear, concise, and exact terms as to enable any person skilled in the art to which it pertains to make and use this invention. This invention is, however, susceptible to

modifications and alternate constructions from that discussed above which are fully equivalent. Consequently, it is not the intention to limit this invention to the particular embodiments disclosed. On the contrary, the intention is to cover all modifications and alternate constructions coming within the spirit and scope of the invention as generally expressed by the following claims, which particularly point out and distinctly claim the subject matter of the invention:

THE CLAIMS

1. A millable block from which a dental prosthesis is made comprising a piece of dental construction material having a plurality of layers having different densities of color arranged in a graduated pattern similar to a tooth, or portions of a tooth, that the dental prosthesis is to replace.

2. The millable block according to Claim 1 where the layers are discrete and vary gradually in density of color from a lighter to a darker color.

3. The millable block according to Claim 2 where the lighter color density corresponds to enamel coloration and the darker color density corresponds to dentin coloration.

4. The millable block according to Claim 2 where the number of layers is from 2 to 30.

5. The millable block according to Claim 2 where the material is selected from the group consisting of composite, plastic, and ceramic.

6. The millable block according to Claim 2 where the layers are substantially parallel to each other.

7. The millable block according to Claim 2 where the layers are substantially cup shaped and nested together.

8. The millable block according to Claim 2 where said piece of

dental construction material is of a suitable large enough size so that the desired prosthesis may be milled from said piece.

9. The millable block according to Claim 2 where said layers are of substantially equal thickness.

10. The millable block according to Claim 2 where the layers vary in thickness, with the layers becoming gradually thicker as said layers progress from the lighter, or least dense coloration, to the darker, or more dense coloration.

11. A millable block from which a dental prosthesis is made comprising

a piece of material having a first side and a second side,

said piece of material including a plurality of layers stacked together and having different color densities similar to different color densities of a tooth, or portions of a tooth, that the dental prosthesis is to replace and varying in density through out the piece of material in a pattern similar to a pattern of variation in color density of said tooth, or portions of a tooth, that the dental prosthesis is to replace, and

said piece of material having a first layer with enamel coloration forming at least a portion of the first side and a second layer with dentin coloration forming at least a portion of the second side.

12. The millable block according to Claim 11 where there is at least one intermediate layer between the first and second layers.

13. The millable block according to Claim 12 where there are a plurality of intermediate layers, said intermediate layers being in a

series of gradually increasing darker density, with the intermediate layer closest to the second layer being only slightly less dense in color than said second layer.

14. The millable block according to Claim 11 where the layers are substantially parallel to each other.

15. The millable block according to Claim 11 where the layers are substantially cup shaped and nested together.

16. The millable block according to Claim 11 where said layers are of substantially equal thickness.

17. The millable block according to Claim 11 where the layers vary in thickness, with the layers becoming gradually thicker as said layers progress from the lighter, or least dense coloration, to the darker, or more dense coloration.

18. A device for making a dental prosthesis, comprising

a platform adapted to be attached to a milling machine, and

a piece of material from which said dental prosthesis is to be made mounted to the platform, said piece of material having a plurality of layers having different color densities similar to different color densities of a tooth, or portions of a tooth, that the dental prosthesis is to replace,

said different color densities varying through out the piece of material in a pattern similar to a pattern of variation in color densities of said tooth, or portions of a tooth, that the dental prosthesis is to replace,

said layers varying gradually in density of color from a lighter to a darker color density where the lighter color density layers correspond to enamel coloration and the darker color density layers correspond to dentin coloration.

19. A dental prosthesis comprising a piece of dental construction material configured for placement in a patient's mouth to replace a tooth, or portions of a tooth, and including a plurality of gradations having different densities of color arranged in a graduated pattern similar to said tooth, or portions of a tooth, being replaced.

20. A method of making a dental prosthesis comprising the steps of

(a) providing a piece of material having a plurality of gradations of different color densities similar to different color densities of a natural tooth, or portions of a tooth, that the dental prosthesis is to replace, and

(b) milling the piece of material to cut away material from said piece of material in a predetermined manner so that said dental prosthesis has a color density pattern similar to a pattern of variation in color density of said natural tooth, or portions of a tooth, that the dental prosthesis is to replace.

21. The method according to Claim 20 where the gradations are discrete layers and vary gradually in density of color from a lighter to a darker color density.

22. The method according to Claim 21 where the lighter color density corresponds to enamel coloration and the darker color density corresponds to dentin coloration.

23. The method according to Claim 21 where the number of layers is from 2 to 30.

24. The method according to Claim 20 where the material is selected from the group consisting of composite, plastic, and ceramic.

25. The method according to Claim 21 where the layers are substantially parallel to each other.

26. The method according to Claim 21 where the layers are substantially cup shaped and nested together.

27. The method according to Claim 20 where automated milling equipment is used to conduct the milling step (b) to make a coronal portions of a tooth, or portions of a tooth, from the piece of material.

28. The method according to Claim 21 where said layers are of substantially equal thickness.

29. The method according to Claim 21 where the layers vary in thickness, with the layers becoming gradually thicker as said layers progress from the lighter, or least dense coloration, to the darker, or more dense coloration.

30. A method of making a dental prosthesis comprising the steps of

(a) providing a piece of material having a plurality of gradations of different color densities similar to different color shades of a natural tooth, or portions of a tooth, that the dental prosthesis is to replace,

(b) providing an automated milling machine including a programmable computer including a monitor screen,

(c) displaying in a selected orientation on the monitor screen an image of the prosthesis to be made and an image of the piece of material to indicate how the different density gradations are to be disposed within said prosthesis after milling,

(d) milling the piece of material according to said selected orientation to cut away material from said piece of material and form said dental prosthesis.

31. The method according to Claim 30 where the automated milling machine includes an input device that enables the image of the prosthesis to be made and the image of the piece of material to be moved relative to each on the screen to select said orientation.

32. The method according to Claim 31 where the image of the prosthesis to be made is positioned within the image of the piece of material, said image of the piece of material having zones corresponding to the gradations of different color densities

33. The method according to Claim 32 where the image of the piece of material is a cross-sectional view having an image of the prosthesis to be made superimposed thereon.

34. A method of making a piece of material used for making a dental prosthesis comprising

stacking together discrete layers of dental construction material having different color densities similar to different color densities of a tooth, or portions of a tooth, for which the dental prosthesis is to

replace,

said layers

(a) varying gradually in density of color from a lighter to a darker color density where the lighter color density corresponds to enamel coloration and the darker color density corresponds to dentin coloration, and

(b) being arranged in a color density pattern similar to a pattern of variation in color density of said natural tooth, or portions of a tooth, that the dental prosthesis is to replace.

35. The method according to Claim 34 where the material is selected from the group consisting of composite, plastic, and ceramic.

36. The method according to Claim 35 where the number of layers is from 2 to 30.

37. The method according to Claim 36 where the layers are substantially parallel to each other.

38. The method according to Claim 36 where the layers are substantially cup shaped and nested together.

39. The method according to Claim 36 where said layers are of substantially equal thickness.

40. The method according to Claim 36 where the layers vary in thickness, with the layers becoming gradually thicker as said layers progress from the lighter, or least dense coloration, to the darker, or more dense coloration.

41. The method according to Claim 36 where the stacked layers are formed by molding, extruding, or forging techniques.

42. A millable block from which a dental prosthesis is made comprising a body of dental construction material having throughout said body essentially the same color hue and gradations therein of color densities that progressively increase in color density from an enamel coloration to a dentin coloration.

43. The millable block according to Claim 42 where said dental construction material has a plurality of discrete layers having different shades of color density arranged in a graduated pattern similar to a tooth, or portions of a tooth, that the dental prosthesis is to replace.

44. A prosthesis milled from a millable block comprising a body of dental construction material having throughout said body essentially the same color hue and gradations therein of color densities that progressively increase in color density from an enamel coloration to a dentin coloration.

45. The prosthesis according to Claim 44 where said dental construction material causes light to reflects polychromatically from said prosthesis.

46. A millable block for making dental prostheses comprising a dental construction material of graduated, multi-shaded densities distributed to cause light to reflect polychromatically from a prosthesis milled from said material

47. A system for making a dental prosthesis from a piece of dental construction material of graduated, multi-shaded densities distributed to cause light to reflect polychromatically from a prosthesis milled from said material, said system including

an automated milling machine including a programmable computer including a monitor screen and input device,

means for displaying on the screen an image of the prosthesis being made and an image of the of dental construction material,

means for selectively orientating on the monitor screen said images to indicate the arrangement of the graduated, multi-shaded densities throughout the prosthesis being made, and

means for milling the piece of material according to said selected orientation to cut away material from said piece of material and form said dental prosthesis.

48. The system according to Claim 47 where the image of the piece of dental construction material includes images of the different layers to assist in orienting the two images on the screen.

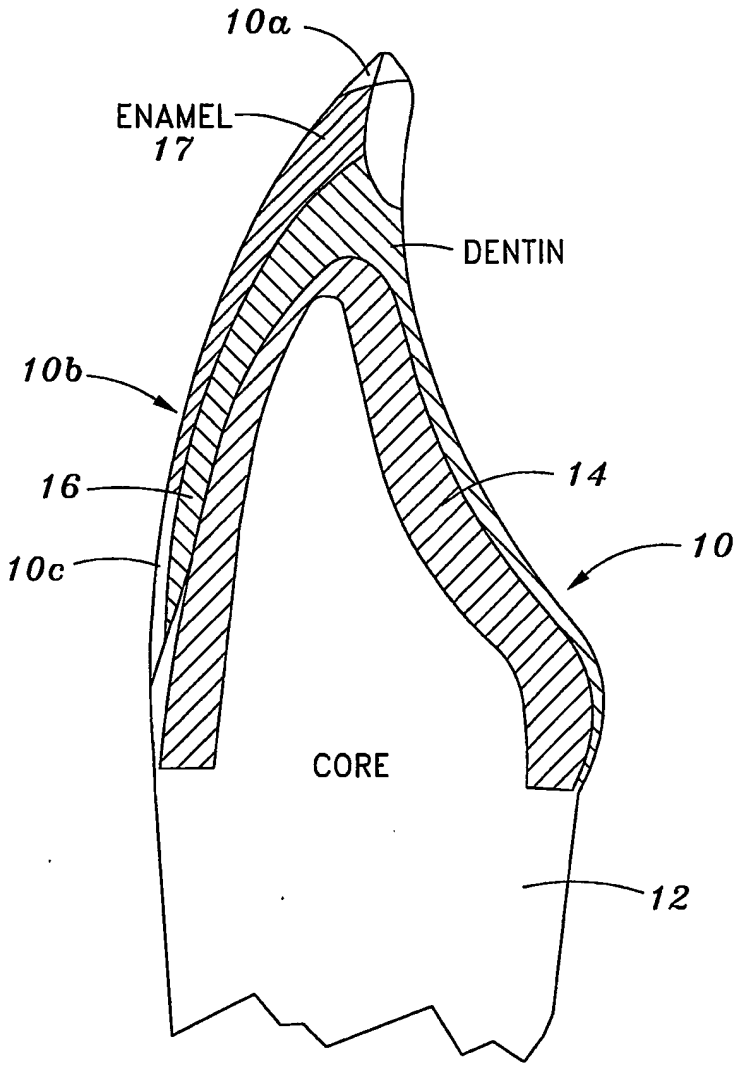

Fig. 1

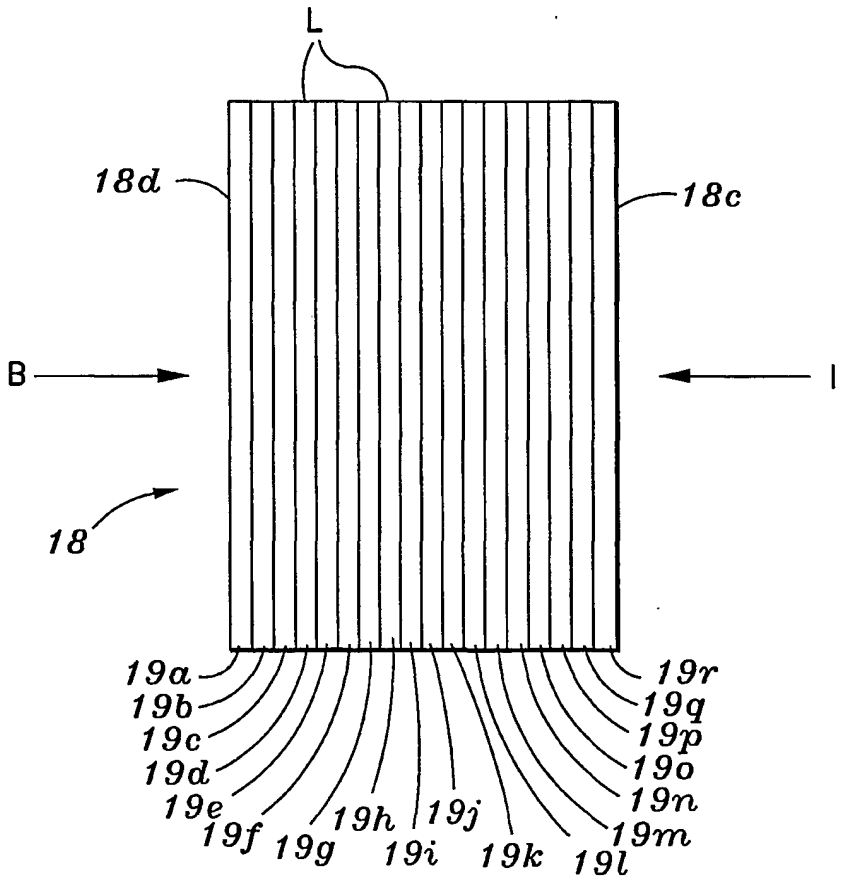
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Fig. 2

Fig. 3

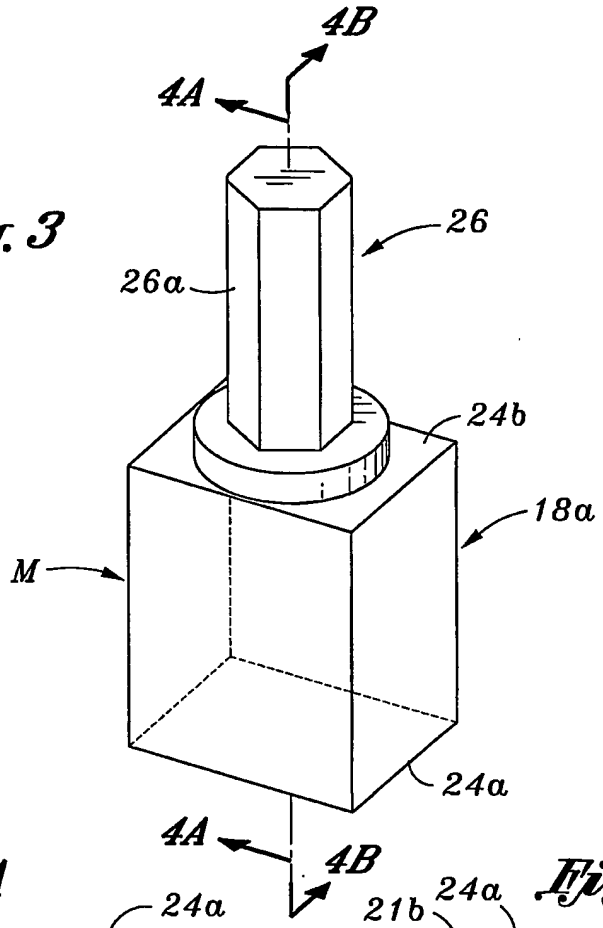


Fig. 4A

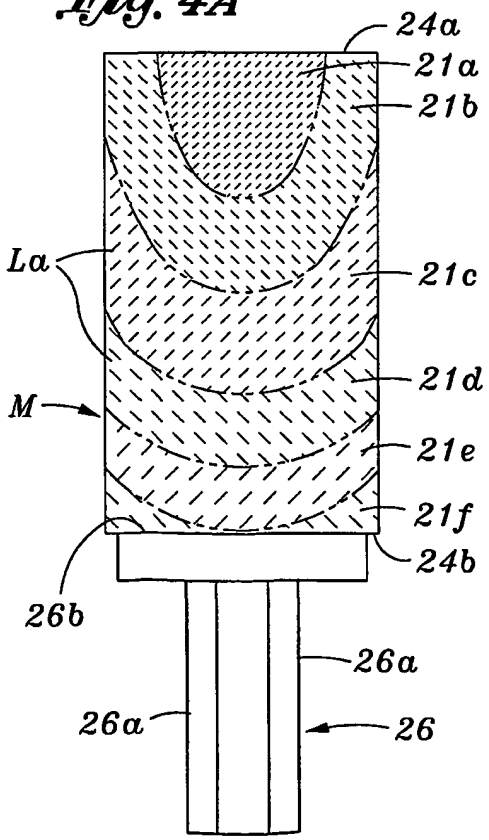
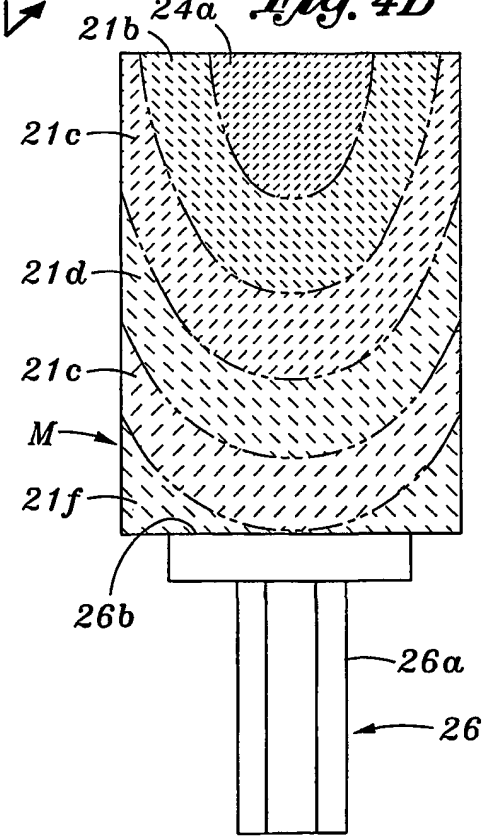


Fig. 4B



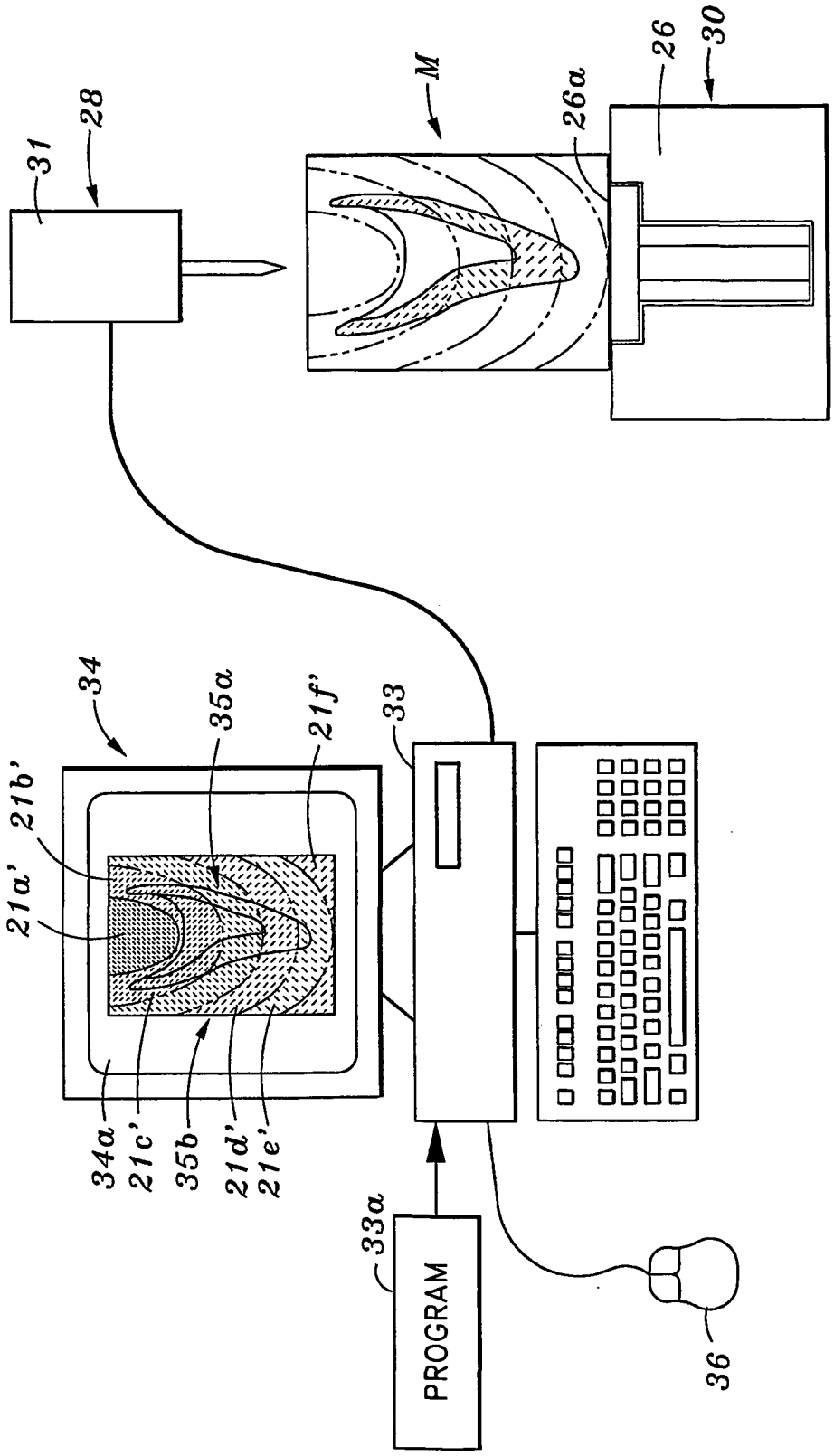

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Fig. 5

Fig. 6

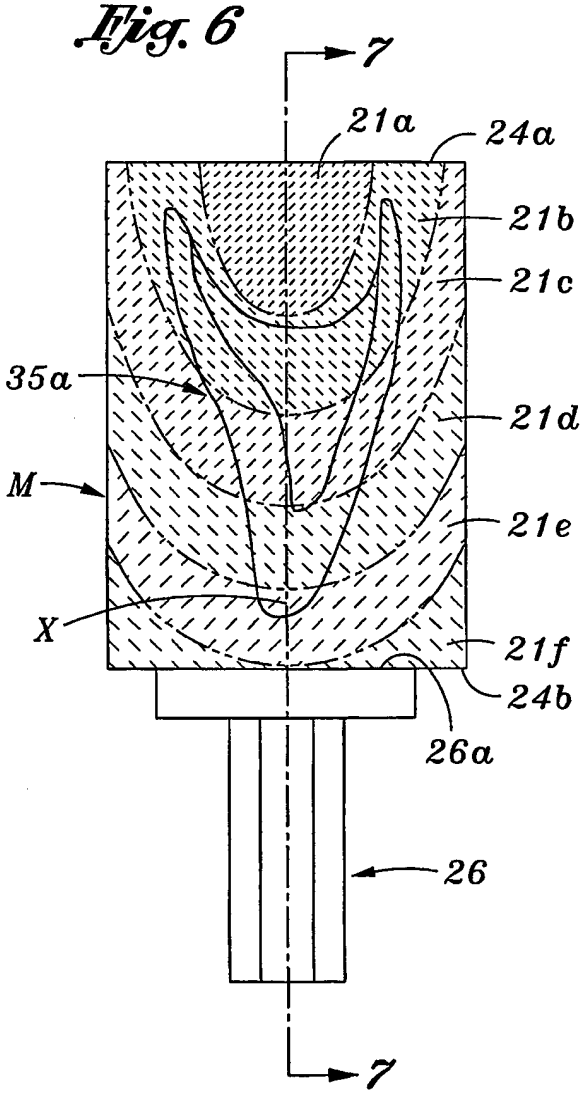


Fig. 6A

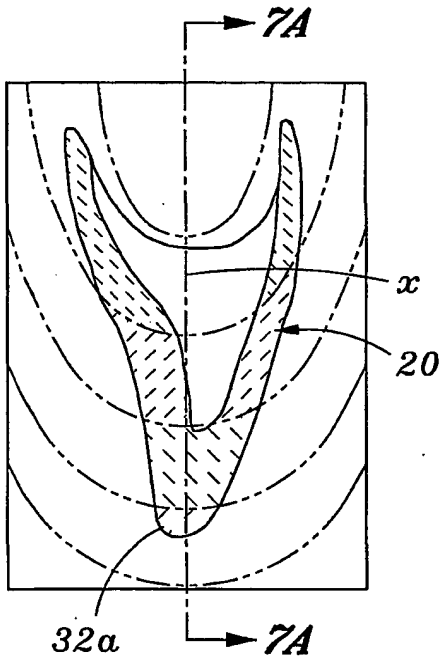


Fig. 8A

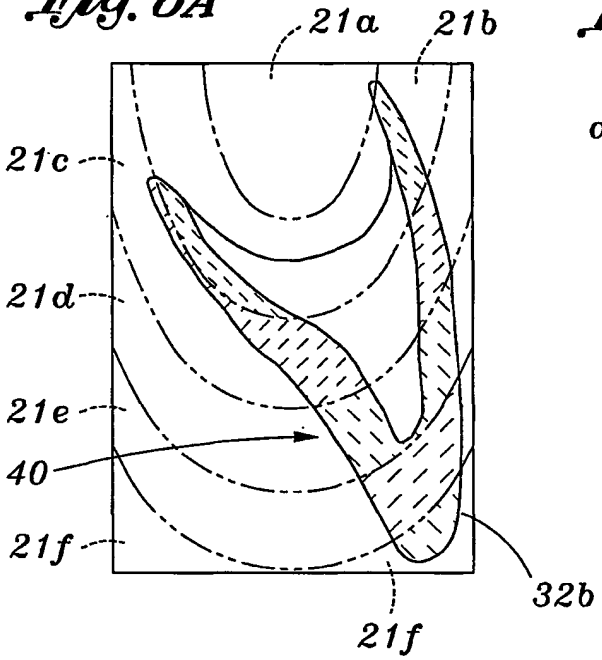


Fig. 8

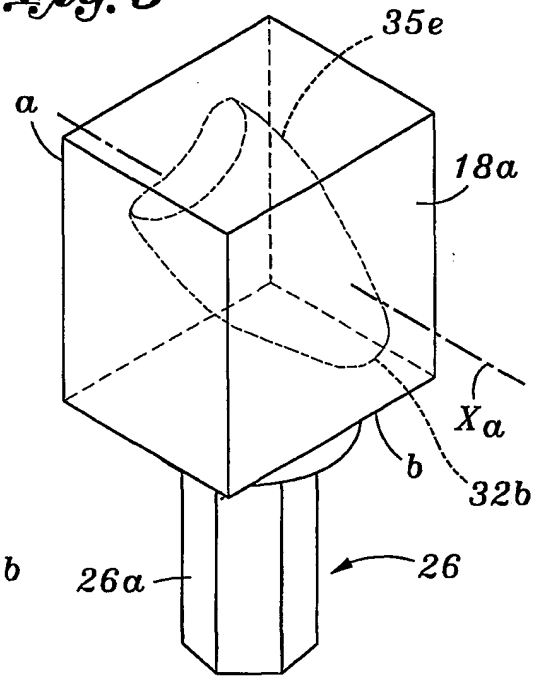


Fig. 7

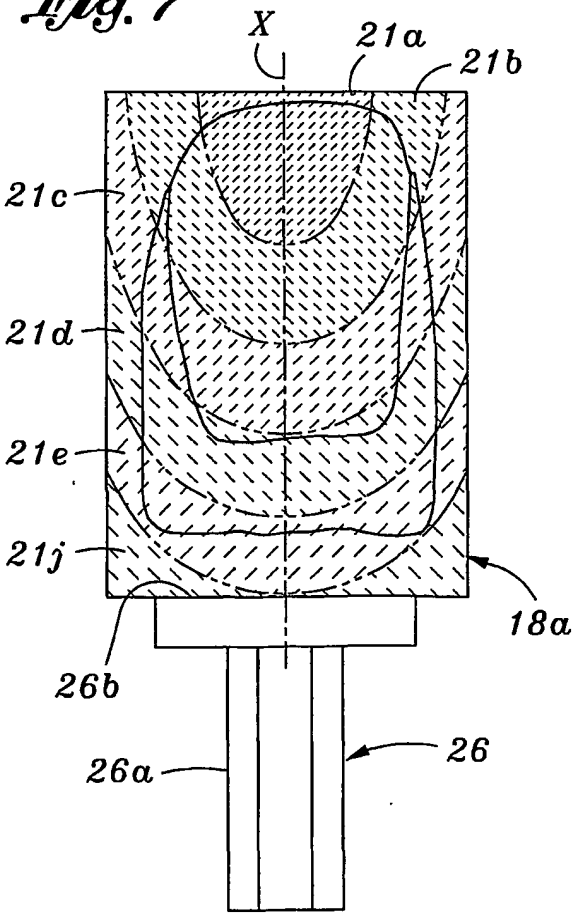
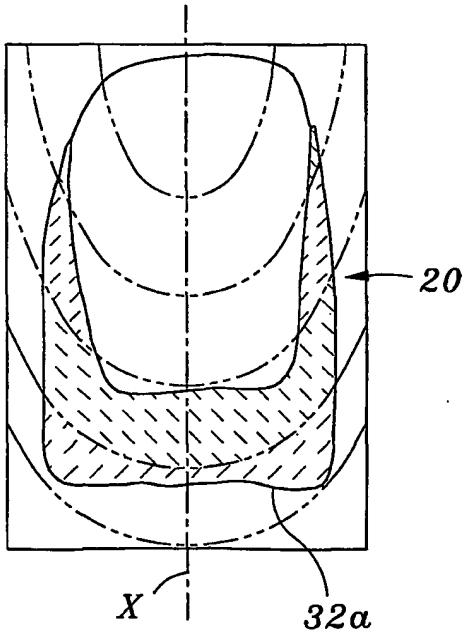


Fig. 7A



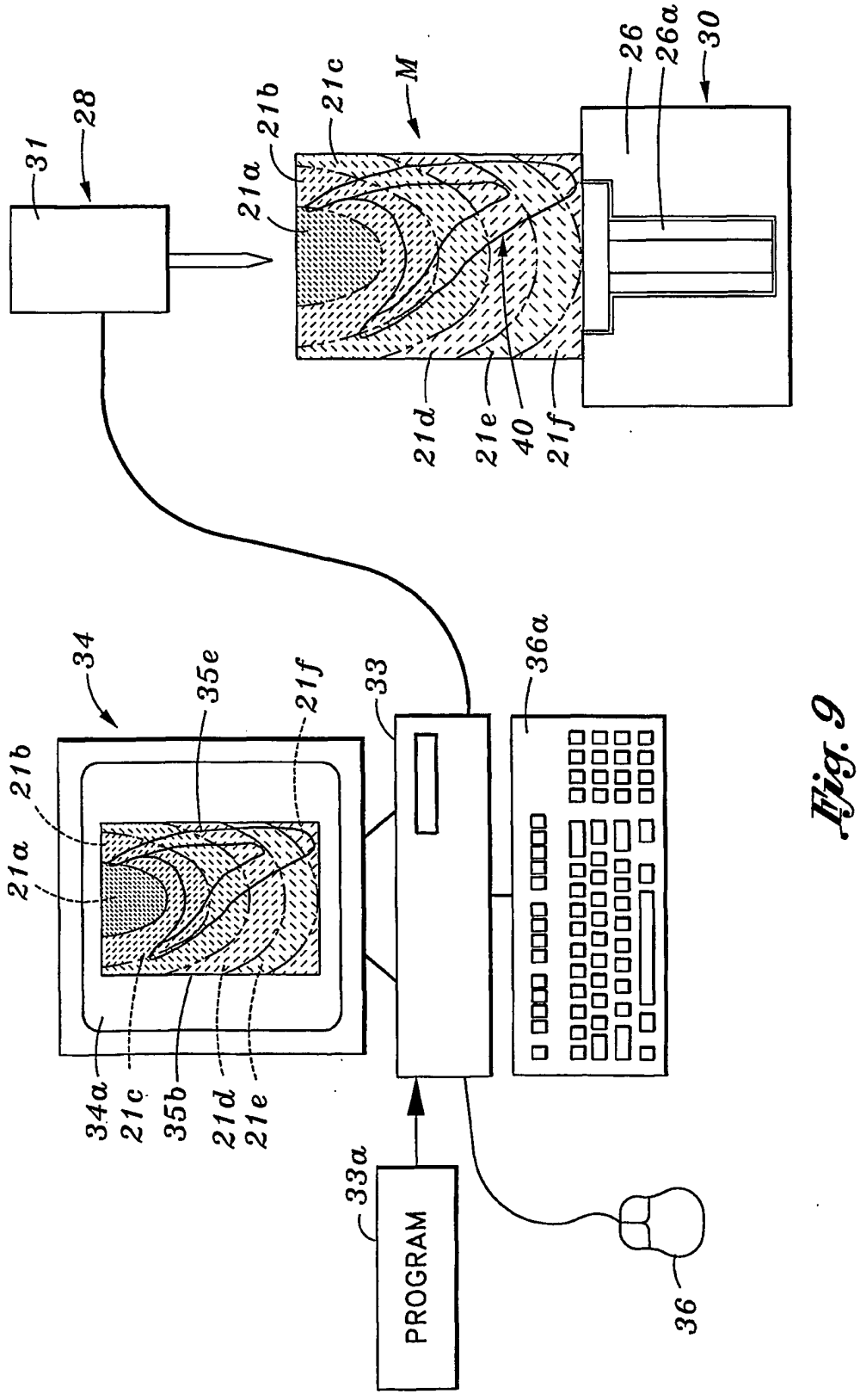

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Fig. 9

INTERNATIONAL SEARCH REPORT

Int[illegible]onal Application No
PCT/US 01/23933

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61C13/09 A61C13/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 151 044 A (ROTSAERT HENRI L) 29 September 1992 (1992-09-29)	1-8, 10-15, 17-27, 29, 34-38, 40-46
Y	column 4, line 14 -column 5, line 54 column 6, line 3-14 figures 1-11	9,16,28, 30-33, 39,47,48

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"A" document defining the general state of the art which is not considered to be of particular relevance

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Date of the actual completion of the international search	Date of mailing of the international search report
14 December 2001	21/12/2001

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Salvignol, A

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INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Y	column 1, line 6-19	9,16,28, 39
A	column 1, line 50 -column 2, line 28	4-6,8, 11-14, 18,21, 23-25, 27, 30-37, 41-45, 47,48
	column 6, line 15-26 column 7, line 39-47	

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A	column 5, line 10-43	6,9,14, 16,25, 28,37,39
	figures 1-10	

X	EP 0 850 601 A (HERAEUS KULZER GMBH) 1 July 1998 (1998-07-01)	1-8, 11-15, 18-27, 34-38, 41-46
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A	column 2, line 34-54	30-33, 47,48
	figures 1-7	

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A	column 4, line 46-68	7,15,26, 38
	column 5, line 10-40 column 5, line 61 -column 6, line 42 figure 1	

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INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 01/23933

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Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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A	page 4, line 5-25	4,5,8, 11,12, 18,23, 24, 30-36, 41-48
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